

Vapor Compression and Thermoelectric Heat Pump Heat Exchangers for a Condensate Distillation System: Design and Experiment

Lisa R. Erickson and Eugene K. Ungar

Maximizing the reuse of wastewater while minimizing the use of consumables is critical in long duration space exploration. One of the more promising methods of reclaiming urine is the distillation/condensation process used in the cascade distillation system (CDS). This system accepts a mixture of urine and toxic stabilizing agents, heats it to vaporize the water and condenses and cools the resulting water vapor.

The CDS wastewater flow requires heating and its condensate flow requires cooling. Performing the heating and cooling processes separately requires two separate units, each of which would require large amounts of electrical power. By heating the wastewater and cooling the condensate in a single heat pump unit, mass, volume, and power efficiencies can be obtained.

The present work describes and compares two competing heat pump methodologies that meet the needs of the CDS: 1) a series of mini compressor vapor compression cycles and 2) a thermoelectric heat exchanger. In the paper, the system level requirements are outlined, the designs of the two heat pumps are described in detail, and the results of heat pump performance tests are provided. A summary is provided of the heat pump mass, volume and power trades and a selection recommendation is made.